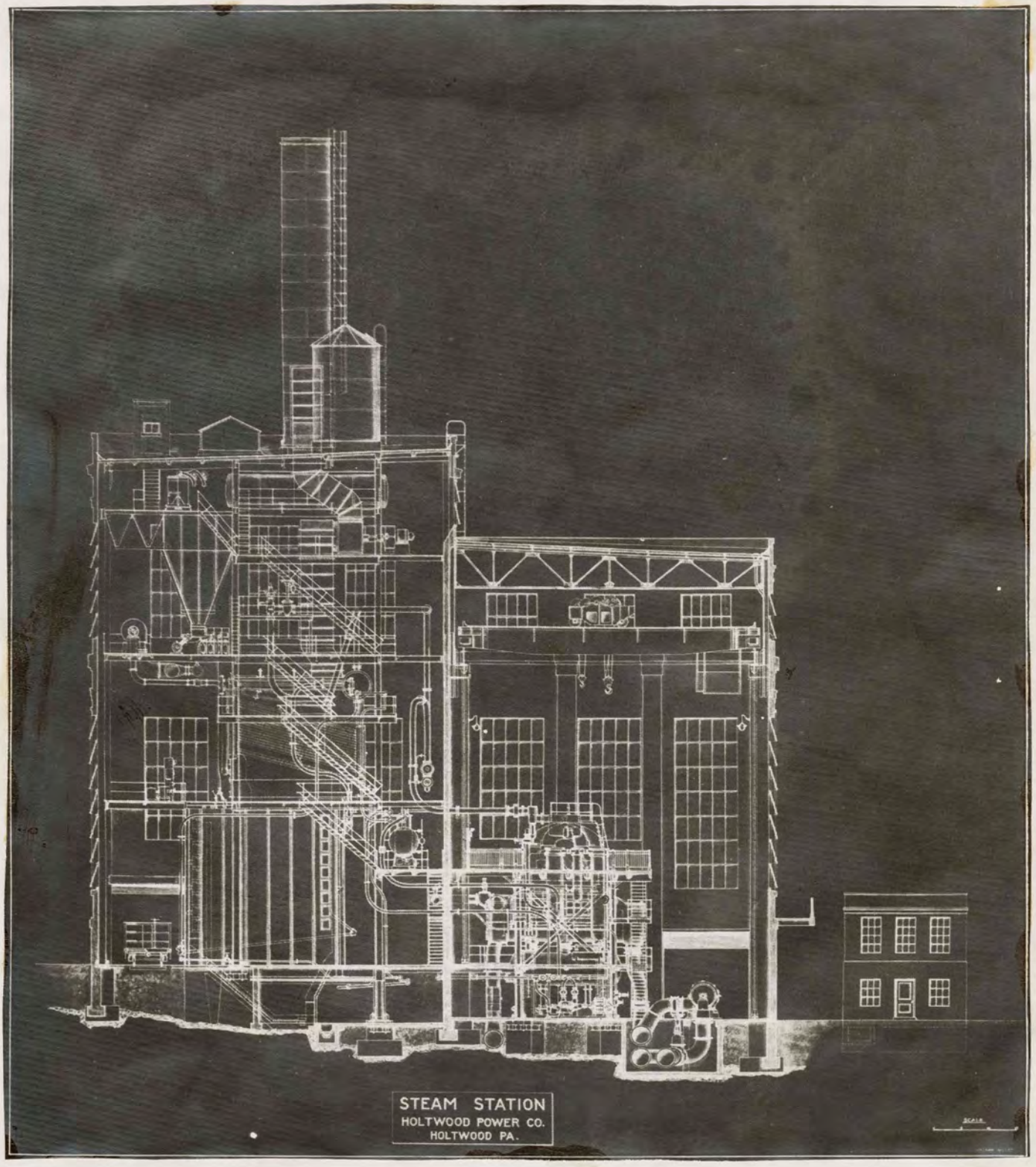
STEAM STATION
HOLTWOOD POWER CO.
HOLTWOOD PA.

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HISTORY AND DEVELOPMENT OF
McCALL'S FERRY (HOLTWOOD) POWER PLANT

by

Robert Lee Mattingly

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December 18, 1936

SUMMARY OF THESIS

This thesis deals with the background of the organization and building of what is now the Holtwood Plant. It treats of the importance of the Susquehanna River and emphasizes the difficulties encountered in the building of Holtwood, especially prior to actual construction. Emphasis is placed on the part outstanding engineers have played in the construction of Holtwood. The development of the equipment of Holtwood is described and the important features of design are explained.

THE HISTORY AND DEVELOPMENT OF McCALL'S FERRY, PENNSYLVANIA

THE SUSQUEHANNA RIVER

Any account of a power development on the Susquehanna River, must begin with the Susquehanna river itself. This river is 450 miles long and has a watershed area of 24,700 square miles 77% of which is in Pennsylvania. With the exception of the St. Lawrence, the Susquehanna river is the largest that empties into the north Atlantic. Despite its size, the river has been of little commercial use until the advent of electricity. This was largely due to the fact that the river's steepest slopes occur near the mouth. In the last forty miles of its course to tidewater, the river has an average slope of 5.6 feet per mile. This is a unique feature of the Susquehanna, and one which has been an important factor is hydro-electric development. This physical condition is of great advantage with regard to hydro-electric power plants, as it means that the best power sites are near the mouth, where the runoff from the entire basin is available, and also near the populous areas and industrial load centers along the Atlantic Seaboard.

THE EARLY HISTORY OF THE McCALL'S FERRY REGION

At the beginning of the twentieth century, the commercial adaptability of the Susquehanna river for producing electrical power became recognized, and a number of promoters became active on the river itself. Perhaps the most notable figure of this time was James H. Harlow. In 1894 Mr. Harlow became interested

in the Susquehanna and spent the remaining twenty two years of his life in efforts to develop the power of the river. Unfortunately, this pioneer never saw any of his dreams realized, as his efforts either never got beyond the paper stage or were abortive for some other reason. Nevertheless, his profiles, gauging and hydrographic work were of great importance to the Holtwood and Conowingo developments.

The early history of electric power projects on the Susquehanna is obscure. Rival promoters became active and conflicting interest obtained properties or rights along the river. All of these activities were stimulated by the recent completion and apparent success of Niagra. One of the first men to become interested in electrical power development in the Susquehanna region, was Fred Stoff. Mr. Stoff, with his associates, organized a company called the York Furnace Electric Company and obtained a power company charter on August 15, 1900. This company planned a project at Duncan's Island, about one and one-half miles below York Furnace, York County, Pennsylvania. Running along the banks of the river was the railroad tracks of the Pennsylvania Railroad The construction contemplated, avoided relocating and raising the railroad tracks, this necessitating a very low dam. Mr. Carey T. Hutchinson and Mr. George S. Morrison became interested in this project and, in 1901, sent Mr. Boyd Ehle to inspect the proposed site. Mr. Ehle found the site to be unfavorable, but investigated further down stream and recommended a site in the vicinity of Cully's Falls. Morrison and Hutchinson approved of a project near Piney Island, which was later developed into the McCall's

Ferry plant. There were several reasons for selecting this site; Piney Island, with the Lancaster County shore forms a natural tail race and the bend in the river tended to throw ice over toward the other side of the river.

THE CONSTRUCTION OF McCALLS FERRY (HOLTWOOD)

Thus the McCall's Ferry plant, now Holtwood was conceived. The entire history of the construction was characterized by delays and difficulties and delays; the first steps were no exception. When attempts were made to purchase the extensive property necessary, a conflict developed with the Harlow interests, who owned the Susquehanna Tide Water Canal rights, part of which was necessary for the McCall project. After lengthy but fruitless negotiations, the work was discontinued until the canal rights could be purchased. This was finally done, in June 9, 1905, a lapse of several years since the original negotiations were entered into. Work was begun in earnest and engineers, headed by Mr. Enle, drew up the plans. The property flooded by the dam was considerable and difficulty was again encountered in acquiring the necessary property. The property owners characteristically demanded exhorbitant prices for the flowing rights and for their property. It became necessary, finally, to lower the crest elevation from 185 feet to 165 feet. This step was opposed by Mr. Enle. Nevertheless, it was probably fortunate in that such a move left sufficient head above McCall's Ferry for a future development. A crest of 185 feet, as originally planned, would have left only about 35 feet head above Holtwood and below Columbia.

With the plans decided on, work was begun in earnest, and bids were accepted. Although bids were received from some of the biggest engineering and contracting firms in the country, the company decided that all of these bids were high, and rejected them. Mr. Hugh L. Cooper, a member of the advisory board, proposed to build the work cheaper, and the contract was awarded to him on a cost plus fee basis. Actual excavation on the site was begun on October 24, 1905.

It must be remembered that all this work was real pioneering and the builders had no precedent to rely upon. In the design of the dam and power house, no idea of the present day power output was ever entertained. Mr. Ehle's statement "The most sanguine hope of the McCall's Ferry Project was to sell one quarter billion kilo-watt hours annually.", contrasts sharply with the estimated total energy sales from of Holtwood in 1935 of 1,354,000,000 kilowatt hours.

The McCall's Ferry Power Company met with financial difficulties and went into receivership in October, 1907, and work under the management of the Hutchinson organization stopped. At this time, the dam was only partially completed and work hardly begun on the power house. Mr. J. E. Aldred, present chairman of the Board of Companies, the Pennsylvania Water and Power Copany, was named receiver on July 17, 1909. The Pennsylvania Water and Power Company, present owners of Holtwood, was organized on January 13, 1910 and the work completed under this management.

The writer has been using McCall's Ferry and Holtwood rather indiscriminately. These names have become synonomous, but it is interesting to trace their origin. McCall's Ferry, of course was the original name of the site of the power development. When Mr. J. E. Aldred became associated with the plant, he renamed it "Holtwood", for Sir Herbert Holt of Montreal and Edward Rogers Wood of Toronto, then members of the board of directors of the Pennsylvania Water and Power Company.

Holtwood was completed in the fall of 1910 and the first kilo-watt hour was marketed on October 14, 1910. So the evolution of the management of Holtwood has progressed; from a few promoters and visionary engineers to the imposing organization of the Pennsylvania Water and Power Company, the most important power organization in Maryland.

It is interesting to note the enthusiasm which greeted the official completion of Holtwood. Mayor Mahool of Baltimore personally turned the switch that sent electricity "dancing back and forth" over the lines between Holtwood and Baltimore. The Mayor's party made a personal inspection of the plant and newspaper accounts of the opening indicate that the whole affair had the atmosphere of a history making event.

THE DESIGN AND DEVELOPMENT OF HOLTWOOD

The design of Holtwood as a whole is worthy of consideration. The plant speakes well for the forethought of its engineers, and compares not unfavorably with some of the more modern plants. It was unquestionable far ahead of its time, for

a comparison with the plant at York Haven, built only two years before Holtwood, will reveal the fact that Holtwood was a tremendous step in advance of the then accepted designs.

After locating the dam site, the dam was designed as an ogee spillway, for maximum flood of 750,000 second feet flood, giving a head on the crest of 17.5 feet. The site of the dam would have resulted in the flooding of the Pennsylvania Railroad tracks, so it was necessary to raise the tracks twenty feet for a distance of about fifteen miles. This was done at a cost of $1,500,000. This extra expense was objected to and an attempt to avoid it was contemplated by designing the dam with a lower head. This was discarded as impracticable and the original plan carried out.

A massive concrete power station was planned to have ten units of 13,500 horsepower vertical shaft turbines and 8333 kva generators with two water driven exciters of 1000 horse poser turbines and 500 kva generators. At the shore end of the power station, was a hollow ice spillway pierced by the car tunnel. This spillway, designed to pass ice that might enter the forebay or the intake to the racks was an excess of precaution and found not necessary in operating the plant.

The gate house room with its racks was covered to protect the operators against bad weather. Skimmer arches were used to prevent floating ice and trash that might pass the intake arches and booms from getting to the racks. It was thought that frazil and anchor ice would not be troublesome because of the long distance upstream to turbulent water, but it developed that the wind effect on the pond also produced the undercooling to make frazil and anchor ice, which floated submerged to the racks

and tended to freeze on and clog them. This prevented either by lifting the racks out and heating them, or using compressed air.

An enclosed forebay was made, by a rock-filled ramp out from the east shore to the end of the intake wall and booms, used to divert floating ice and drift. The downstream end of this intake wall joined the dam and station. As the forebay was in the lee of the projecting bend at McCall's Ferry, most of the floating material was deflected away from the intake to the west side of the dam.

To prevent large fluctuations of head by access of floods to the tailrace at the station, a wall was built from the east end of the spillway to Piney Island and minor crib and fill dams at low places in the string of islands to the head of Cully's rapids.

An amusing sidelight to the more technical details of the construction was the trouble the Company had with fish. When the dam was built, nearby property owners protested that the dam would kill all the shad in the nearby waters. Guided by the State Fish Commission, the Company obligingly built fish ladders over which the shad were expected to climb. While the fishway was built on the plans of the State Fish Commission, it failed to entice the shad to ascend, possibly because they were not given to such acrobatic stunts as are trout and salmon. Later, when this was fully demonstrated, the Commission required another fish-way built in a different position, but this also proved futile and further experiments at the expense of the Company were closed. Incidentally, the shad did eventually die out but not because of the dam. Unrestricted seining so reduced their numbers

that they became practically extinct in that region.

The power station was on the face of the reservoir wall section of the dam pierced by intakes to the ten units, divided into four sections by thin concrete piers having the gate recesses. Racks of flat iron bars rigidly held by rods with pipe spacers in panels of five sections in length, sliding on concrete recesses upstream from the intakes, prevented entrance of floating trash from the gate house pool inside of the back wall with its submerged intake arches six feet below the dam crest. A bridge crane traveling the length of the gate house was designed to handle racks, gages and material. The original wooden gate designs have been changed to steel lift gates.

Running along the front of the reservoir wall section at the back of the station was the rheostat gallery, supported by thin butress walls pierced by arched doorways. In the generator room were the ten electric generators on vertical shafts over their Francis twin runner turbines in cellular concrete pits. Over the generator floor was the traveling bridge crane for handling equipment.

The first five generators were 8333kva, the largest then available, for which it was necessary to use two turbine runners to a shaft as it was prior to the large spiral intake single runner turbines which came out as these first turbine units were being installed. Turbine units one to eight have double runners. Later the Pennsylvania Water and Power Company cut out the concrete of the double runner turbine pits and installed single runner spiral intake turbines, with the Moody cone draft

tubes, thereby increasing the equipment installation from 135,000 turbine horse power to 158,000 in the completed station.

In the middle of the station, between units 5 and 6 are the two water driven 1000 horse poser exciters. All main units were equipped with Kingsbury babitted bearings.

At the front or outflow side of the generator room, arches of the construction bridge through which the divided draft tubes discharged, were utilized as the foundation of the bus and switch rooms.

The final power station is, therefore, of composite design, showing the evolution in design from 1905 to 1924. It must be added that in 1925, an auxilliary steam power plant was added utilizing the coal in the river bed which could be recovered very cheaply. Adequate treatment of this, the latest development of Holtwood would demand extensive explanation and will not be attempted .

Proving that back-sight is more reliable than fore-sight. some features of Holtwood can be criticized. Among the faults of the power station was the use of massive concrete, unreinforced against temperature cracks, poor ventilation and lighting, and too complex and constricted arrangement of floors and passages. Some desireable features were not possible in construction because they were yet undeveloped, such as the single runner spiral turbines, improved draft tubes, deep intake gates, out-door types of transformers and switch yard as appear in the more modern Conowingo design.

Any criticism, however, must of necessity be a trifling

one and can in no way dim the lustre of the achievements of the designers, builders or operators of Holtwood. Holtwood has been rightfully called a laboratory. Take four successive cross-sections i.e., the first double runner units, unit No. 8, units Nos. 9 and 10, and the Safe Harbor section, and a graphical history of the progress that has been made in low head turbine designe during a 25 year is presented.

We as engineers, must recognize the importance of Holtwood, and acknowledge it as an important milestone along the road to Engineering Knowledge.

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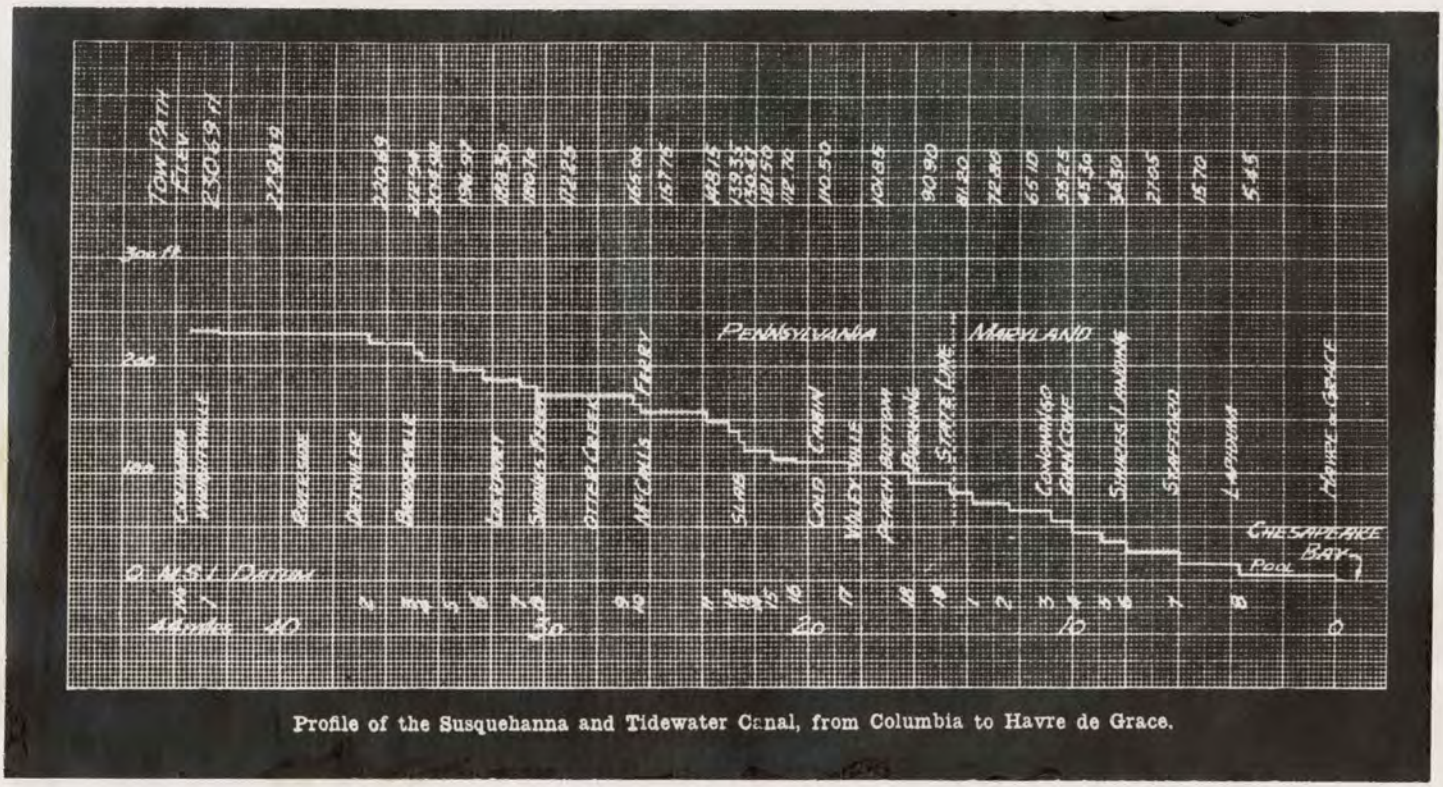
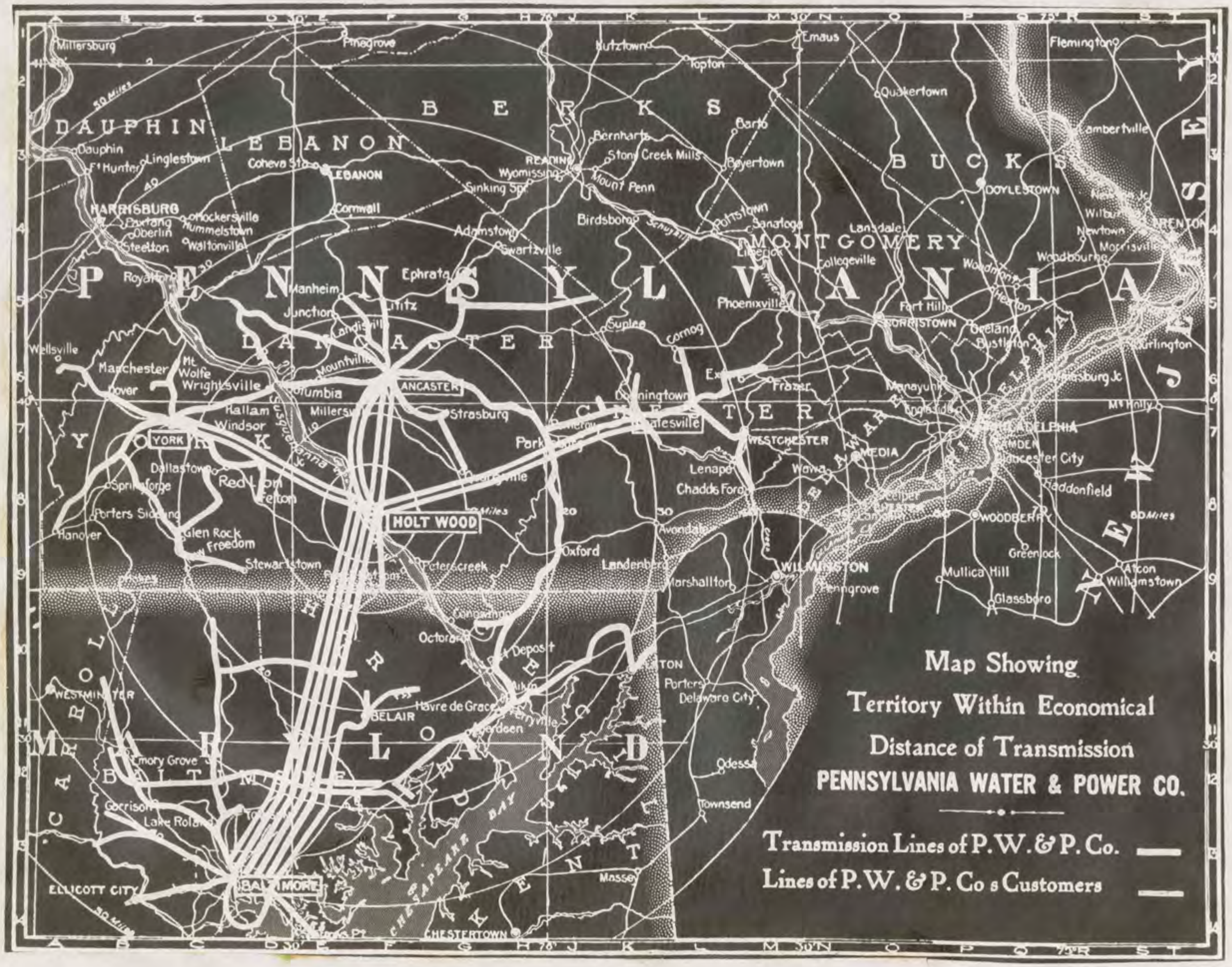
Baltimore American, Saturday, October 15, 1910.

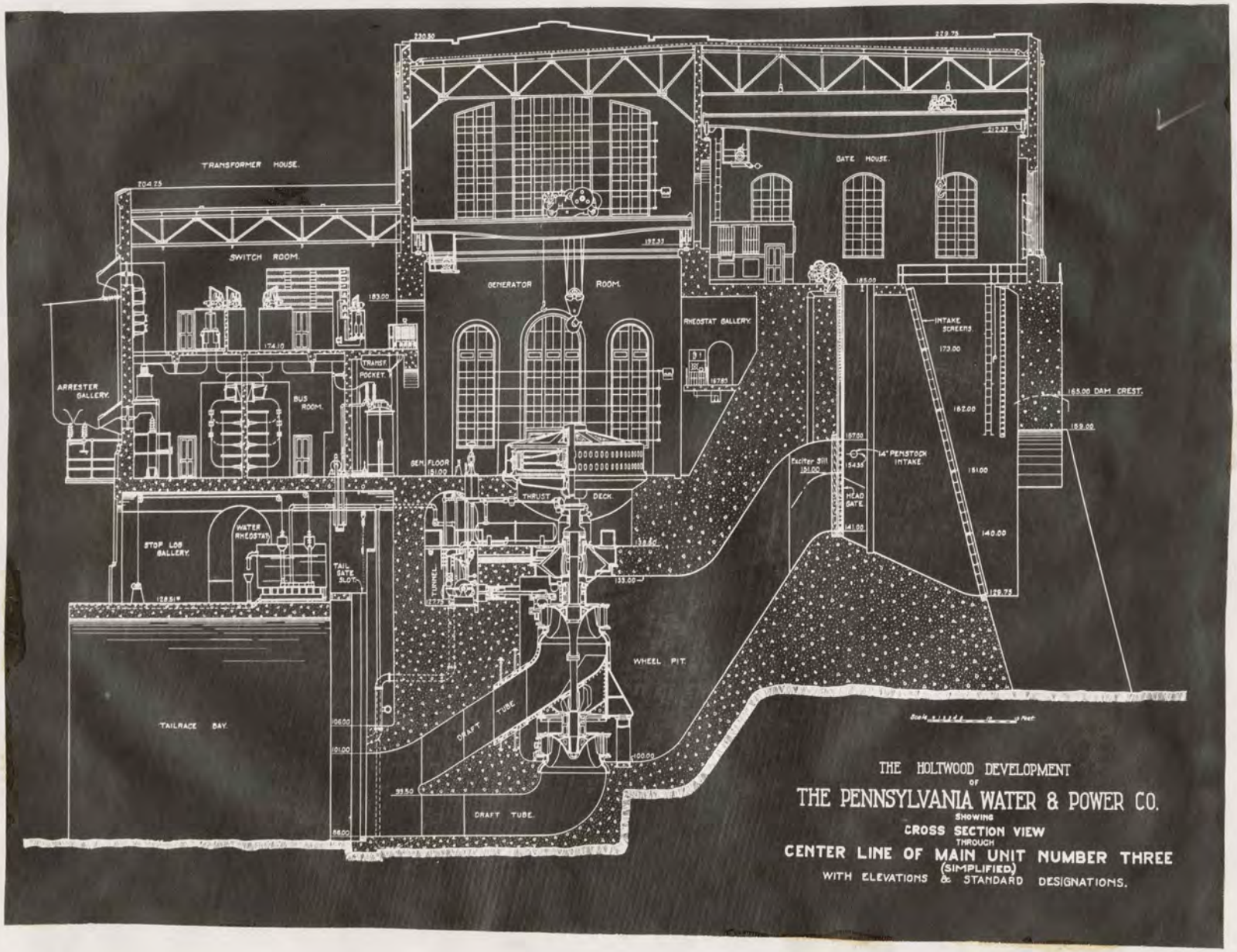


Profile of the Susquehanna and Tidewater Canal, from Columbia to Havre de Grace.

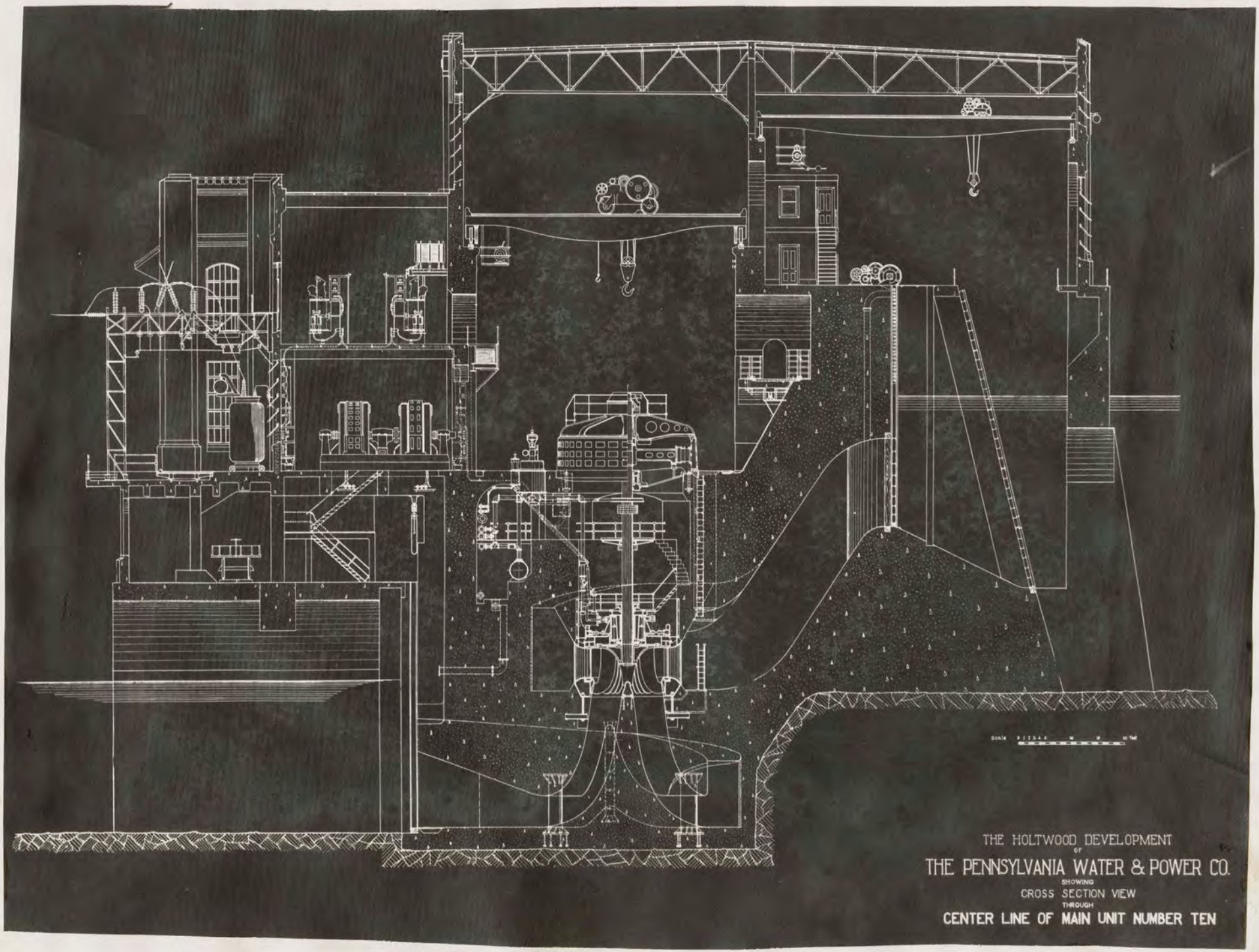
Profile showing unusually steep slopes of Susquehanna.

DAM AND POWER HOUSE FROM YORK COUNTY SHORE WITH FLOOD PASSING OVER THE DAM


Map Showing
Territory Within Economical
Distance of Transmission
PENNSYLVANIA WATER & POWER CO.
Transmission Lines of P.W. & P. Co.
Lines of P.W. & P. Co s Customers
PENNSYLVANIA
MARYLAND
NEW JERSEY
DAUPHIN
LEBANON
BERKS
BUCKS
MONTGOMERY
LANCASTER
CHESTER
YORK
BALTIMORE
CARROLL
HARFORD
CECIL
KENT
DELAWARE
CHESAPEAKE BAY
HOLT WOOD
BALTIMORE
LANCASTER
YORK
HARRISBURG
LEBANON
READING
PHILADELPHIA
WILMINGTON
WESTCHESTER
NORRISTOWN
DOYLESTOWN
TRENTON
CAMDEN
MEDIA
WESTMINSTER
BELAIR
ELLICOTT CITY
CHESTERTOWN
WOODBERRY
Millersburg
Pinegrove
Kutztown
Topton
Emaus
Flemington
Quakertown
Lambertville
Dauphin
Linglestown
Cornwall
Manheim
Lititz
Ephrata
Columbia
Wrightsville
Strasburg
Oxford
Hanover
Glen Rock
Stewartstown
Havre de Grace
Perryville
Aberdeen
Emory Grove
Lake Roland
Delaware City
Odessa
Townsend
Phoenixville
Coatesville
Avondale
Landenberg
Marshallton
Chadds Ford
Lenape
Haddonfield
Glassboro
Mullica Hill
Williamstown
Birdsboro
Boyertown
Wyomissing
Mount Penn
Stony Creek Mills
Collegeville
Lansdale
Burlington
Gloucester City
Mt Holly
50 Miles
50 Miles



THE HOLTWOOD DEVELOPMENT
OF
THE PENNSYLVANIA WATER & POWER CO.
SHOWING
CROSS SECTION VIEW
THROUGH
CENTER LINE OF MAIN UNIT NUMBER THREE
(SIMPLIFIED)
WITH ELEVATIONS & STANDARD DESIGNATIONS.



THE HOLTWOOD DEVELOPMENT
OF
THE PENNSYLVANIA WATER & POWER CO.
SHOWING
CROSS SECTION VIEW
THROUGH
CENTER LINE OF MAIN UNIT NUMBER TEN